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EDITORIAL DEPARTMENT NOTE

If anything, cost estimating has increased in importance with the introduction of the negotiated type of government contract. There are many features in estimating the cost of government contracts which are not present during normal times in connection with commercial business, and the cost estimator who is to render the greatest service to his company must keep abreast of new developments and anticipate unusual costs and situations. The article on cost estimating for government contracts in this issue of the *Bulletin* will provide guidance in this area.

The author of this article is Max F. Thompson, Works Accountant for the Whitin Machine Works, Whitinville, Mass. After graduating from the Carnegie Institute of Technology, Mr. Thompson was employed for a time with the United States Steel Corp., and later served the Westinghouse Electric & Manufacturing Co. for a period of eleven years in various accounting capacities, much of his time being devoted to system installation. This was followed by several years in public accounting before Mr. Thompson joined his present company. Mr. Thompson is a member of the Worcester Chapter and is currently serving as chapter Director of Program.

Our second article deals with cost accounting for a manufacturing operation which has received little consideration in industrial accounting literature. The article describes the standard cost methods for handling heat treating costs which have been developed by The Caterpillar Tractor Co.

The author of this article, George T. Krider, is Chief Accountant of The Caterpillar Tractor Co., a position he has occupied since 1930. Prior to joining this company 23 years ago, Mr. Krider served as Secretary and Auditor of the *Peoria Transcript* and Auditor of its successor, the *Peoria Journal-Transcript*. He has also served as Traveling Auditor and Auditor of Receipts for the Illinois Traction Co. Mr. Krider is a native of Bloomington, Ill.

Articles published in the *Bulletin* present many different viewpoints. In publishing them the Association is not sponsoring the views expressed, but is endeavoring to provide for its members material which will be helpful and stimulating. Constructive comments are welcomed and will be published in the Forum Section of the *Bulletin*.

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COST ACCOUNTANTS

JULY 1, 1942

COST ESTIMATING FOR GOVERNMENT CONTRACTS

By Max F. Thompson, Works Accountant,
Whitin Machine Works, Whitinville, Mass.

It is Friday afternoon. The new job to be quoted on is "in the mill." It will have to move along fast—they want those figures in the hands of the Contracting Officer by Monday morning. By now the purchasing agent is on the phone getting prices from Pittsburgh on that special size of steel in that alloy you never heard of before. The tool and methods man has sent back a few of the blue prints so that the labor estimator can get started. He is working on them now, frowning over his slide rule.

The quotation will get out on time all right; there is just one thing that is disturbing. It's too bad this has to go through in such a hurry. This is a big job and the firm could take a sizeable loss if the estimate were low. The superintendent didn't seem too positive, either, when he said that those old grinders could hold the large diameter to plus 0".0000 and minus 0".0004.

The Safety Factor

There will have to be a safety factor added—a generous one, and you must decide how much.

At this point many a cost accountant comes to grips with his conscience. Here is a decision of real significance and undoubtedly one of the main reasons for the frequent wide range of bids between the highest and the lowest bidder.

The first impulse is simply to get plenty of margin for whatever may happen—to play safe. But now another responsibility must be considered; this is war work and it seems like treason to take an unnecessary dollar from the arming of our country. A forewarning of the trend of public opinion on excessive war profits can be taken from the publicity given to the disclosures of the Truman Committee in the Senate and of the House Naval Affairs Committee. Indignation has run high over these charges of profiteering and even some who were innocent victims of misstatements and half-truths have suffered embarrassment. And

finally, if the foregoing leaves you unmoved, there is always the chance that someone will underbid you.

So there is danger too in "playing safe" and we know that the safety factor must be kept to a minimum. It was a poor substitute for careful estimating anyway. Let us check over some of the points wherein war contracts are different from the usual ones, put in all that belongs in and keep the safety factor down to the very minimum.

Negotiated Contracts

Government contracts today are much more frequently awarded by negotiation than after open competitive bidding. The object of this departure from usual government practice is, of course, to save time. When open bids are advertised the entire waiting period may elapse before it is discovered on the opening day that no acceptable bids have been received. Under direct negotiation this condition would have been discovered much earlier and the contracting officer would have had an opportunity to seek out new sources of supply. Direct negotiation between the government and the contractor may also disclose instances of insufficient productive capacity with the minimum of delay. For example, when the Army undertook last year to place orders for large quantities of cotton duck, textile manufacturers were invited to bid on a small portion of the total requirements. It was expected that the prices quoted would provide an indication of the entire cost of the program, and each supplier was thought capable of producing all or most of this smaller quantity. Not until the bids were finally opened was a serious situation revealed. The combined capacity (at that time) of all the manufacturers was insufficient to produce even the partial amount required in the time specified.

From the contractor's standpoint the "negotiated bid" method has both advantages and disadvantages over the open bid, but the first steps—getting information for the bid—are quite similar.

Getting Information

Listed below are some of the points which the estimator should check when getting his information:

1. Get the analysis of the material specified—unless you are already familiar with its properties. Remember that the

labor estimate depends upon knowledge of the machineability of this material. Also, it may save time to have the exact analysis when getting quotations on raw material.

2. Determine what priority rating and urgency number will be extended, not only for materials but for tools and equipment which may have to be purchased.
3. Inquire as to whether the raw material will have to be inspected at the source or at your plant.
4. Get samples, if possible, if the product is unfamiliar to you and the contract sizeable. It may be possible to get permission to observe the manufacture of this same article at some other plant. Co-operation of this sort between suppliers has become quite common, and it often happens that information regarding the peculiar difficulties of a job may be learned this way and mistakes avoided.
5. Inquire regarding methods of packing which are permissible. Packaging may constitute an important element of cost, and some packing supplies have become quite scarce.

Assistance from Contracting Officers

Valuable assistance of a technical nature may be obtained from the contracting officer who is usually eager to assist the prospective contractor in the solution of his problems. It is true that there is some restriction on the assistance which can be provided:

> "No person who sustains at the time, an active relation to the military or civil administration under the War Department will render assistance to bidders in the preparation of bids."—Code of Federal Regulations, Title 10, Ch. VIII.

However, it often happens that the approximate price *range* may be made known to the contractor, thus preventing a loss of time if his facilities will not permit him to compete.

The government arsenals are required to manufacture a certain amount of almost all munitions which are purchased and advice as to machining methods, speeds and feeds, and even the required

machining time may be made available to the prospective contractor.

If the prospective job is a subcontract then the difficulty may be that too much information is available. Often the prime contractor will use his own cost figures in an attempt to dictate the price from the subcontractor. Often this takes the form of an agreed price per hour which is extended by the number of hours required by the prime contractor to perform the work. When a proposal of this sort is offered, the safest procedure is to obtain a detailed breakdown—operation by operation—of the time in the prime contractor's cost figures. These operation costs should be checked by your own shop methods man to determine whether the time values can be met with the equipment available, and adjustments should be made where necessary.

Labor Estimates

Estimating the labor cost on unfamiliar work should not be a one-man job. The estimator who is experienced with methods and costs on regular work may make dangerous assumptions of similarity on strange materials, with closer tolerances and on products which are subject to government inspection. It is definitely advisable to have such proposals reviewed by the tool designer, the shop methods man and the rate setter as well as the cost estimator.

Each person coming in contact with government work for the first time should be impressed with the difficulty of meeting government specifications. Frequently speeds and feeds have to be lowered; the operator may have to inspect as he produces; and almost always the final inspection cost is greater than in industrial practice. Point to point inspection on 100 per cent of the pieces is the usual rule on such work. In brief, defense jobs take longer to produce than similar industrial jobs.

The labor estimate must include not only provision for extra time, but possibly for higher rate of pay, due to:

1. *Overtime bonus* required to meet the schedule of deliveries. (Later on, the accounting department may not charge the overtime bonus to direct cost, but it must be included in the estimate somewhere.)

2. *Shift allowances* granted as compensation for working second or third shift.

3. *Day work allowances* if the job must be done on day work by an operator who is to be compensated for loss of production bonus.

4. *Higher rates* of the skilled labor necessary, in comparison with average rates used for usual work.

Of course any increase in the labor base brought about by the inclusion of labor which is ordinarily in overhead, should not be permitted to inflate the burden applied. A dollar of overtime bonus is only that and not an excuse to add $1.65 of burden.

Treatment of Overtime Bonus

Continuing our analysis of the special problems of preparing quotations on defense bids, let us now consider the overhead rate. This is a subject that can cause a good rousing debate wherever there are two accountants within shouting distance of each other, because of the conflict between established methods and the need to anticipate new factors in overhead.

It has become usual to start any consideration of overhead with the problem of overtime bonus and I see no reason to be unconventional in this respect. The question here is one of allocation. If overtime bonus is charged off to expense, then the cost of each labor operation will be burdened proportionately to the productive hours—(or machine hours, or value of productive labor, depending on the basis used to apply overhead). If a proration of *actual* overhead is custmarily made, then the actual experience during a given time is reflected in the cost records—the historical cost records—and if the new work on which the quotation is being made will not require more overtime, then past actual overhead rates will suffice for estimating costs. However, if standard overhead rates are to be used, then we must inquire as to whether these rates contain sufficient provision for overtime bonus under the operating conditions anticipated. If not, the rate may be adjusted to include the bonus, provided the adjustment is not cancelled out by other factors, such as favorable volume variance which may be undesirable on government contracts where costs should be realistic and factual.

Both of the foregoing methods are open to criticism if non-defense jobs are to be performed along with defense work and if they require either more or less overtime. This brings us to the most controversial point of the whole subject. Should the overtime bonus be applied directly to each job on which it was required, or is it satisfactory to distribute the cost by some arbitrary method?

Direct Application of Overtime Bonus

Direct application has some advantage of validity in the event your cost records are later questioned. It is possible to show the date, the operator, the rate of pay and the operation; thus the records can provide excellent supporting detail. If this method is used, the estimate for quotation can be figured as in the following example:

For each operation it is necessary to foresee the working hours of the operator, considering the machine load imposed by the new work and other pertinent factors. Let us suppose a schedule of 50 hours per week. At time and a half after 40 hours this would pay the equivalent of 55 hours at straight time, or, a 10 per cent increase. If the labor rate to be used is, say, 80 cents then 88 cents times the estimated hours will provide for overtime bonus in the labor estimate.

The direct application method has two definite disadvantages. First, is the difficulty and expense of making the allocations to all of the job cards which may be involved. Second, is the indisputable fact that many urgent jobs are actually performed during regular hours—escaping without any burden of overtime bonus, and forcing the less urgent jobs into the later hours of the day or week when the bonus becomes effective.

Summing up the problem of overtime bonus, it appears that there is no one best way to handle it. The choice of method depends on the conditions which apply.

Other Overhead Problems

The cost of setups is often buried in the standard overhead rates, and it may be well to consider whether the provision for setups in a government cost estimate will be proper. If a sizeable adjustment is indicated, the setup provision may be eliminated

from the overhead rate—reducing the burden applied—and a separate calculation made of setting-up expense based upon quantities desired, production schedules and tool life. If the machine has to be held idle while the first, or "pilot," piece is approved, this loss may be included in setup cost, if appreciable.

Other adjustments of standard burden rates may be advisable for such reasons as: rearrangement of equipment, minor alterations to buildings, learning time and instruction time, extra supervision and inspection, higher scrap loss, increased protection by special watchman, etc.

The overhead rate should fit the operation. If the regular rates are composite rates—that is, including different types of operation—it will be necessary to break them down to suitable divisions. For example, the standard rate for a department making gears might cover both a battery of automatic gear-cutters (four to each operator), and also a number of ordinary lathes each run by one man. This arrangement would have been satisfactory when the normal flow of work used the two types of machines in consistent proportion. However, if the quotation is for gear-cutting only and no lathe work, then obviously the composite rate will not suffice, and an individual overhead rate must be computed for the gear-cutters.

An unexpected element of cost came to our attention recently in reading the specifications for some shell parts. It was required that a certain percentage of these parts be subjected to a destructive test to determine their ultimate breaking point. Accordingly we increased the factory cost by this percentage.

Comparison of Open Bids

An opportunity for checking cost estimates for open bids is available and should not be overlooked. An abstract of all the bids received for each offer under the competitive bid system, should be obtained and analyzed.

First the bids should be reduced to a common basis as regards quantity discounts, delivery charges, etc.; then the relation of your own bid to the others can be studied. A frequency chart type of graph similar to Exhiibt 1, which has the unit price on the horizontal or X axis and the frequency that each price is received on the Y axis, gives a good visual picture of the groupings of the

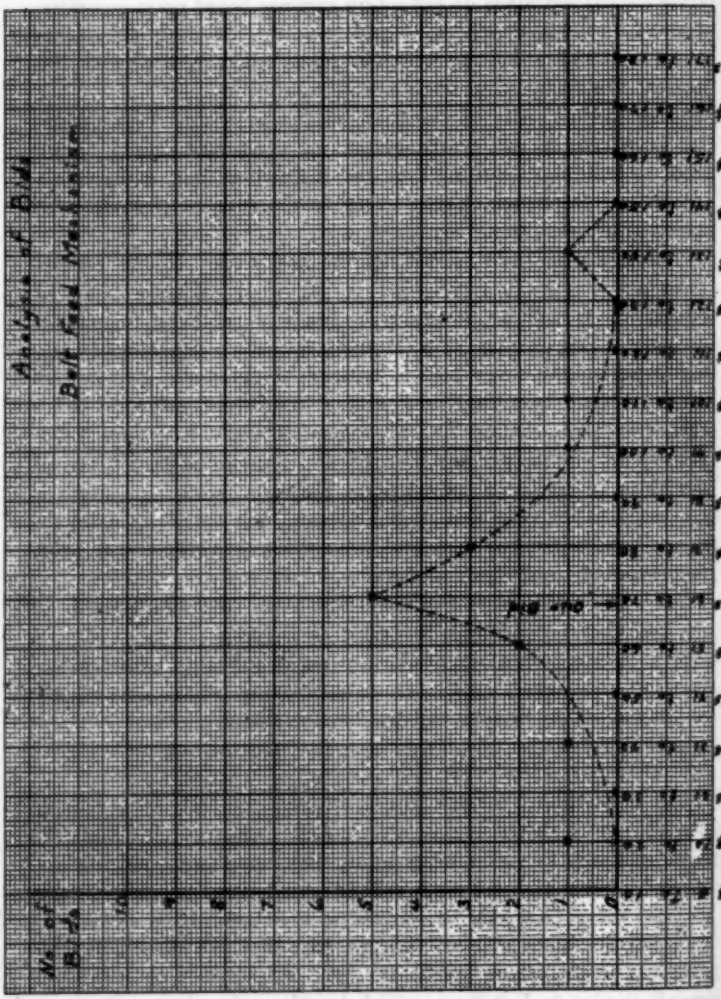

EXHIBIT 1

bids and the comparative location of your own. If these prices are reduced to index numbers, then a succession of jobs may be plotted. Of course, the value of such a comparison is in proportion to the number of instances studied. A definite tendency to be among the highest bidders may indicate the necessity of reducing future quotation prices, or, if your own bids are consistently far below your competitor's, this may be taken as a warning to review the cost methods in use.

Load Charts

In estimating large quantities of special work the problem of delivery dates is vital. In order to win this war there will have to be an absolute minimum of failure to meet schedules and to do this an accurate and up-to-date load chart must be maintained for use in making the delivery promises required at the time of quotation. The cost estimator has a part in this planning, since his time estimates and operation lay-outs must be used in the forecasts of production.

For this purpose the estimator in one defense plant keeps a record, as the cost estimate is compiled, of the unit time required of each type and size of machine to be used. Each operation is posted on a work sheet which provides for each machine classification an analysis and total in terms of machine hours. These work-sheet totals are posted first to a schedule of "Bids Entered Pending Award," and then, if the award is received, transferred to the regular production load chart. Each of these records is analyzed by machine-hours per week for each type of work.

Control of these charts and the responsibility for delivery promises is in the hands of the production department.

Proof of Responsibility

Proof of responsibility is merely the proof required by the government that you are able to perform the contract. This varies from one agency to another and may be nothing more than a certified statement of condition which may not even be required to be signed by C.P.A., or it may be a bond up to 100 per cent of the value of the contract. On recent contracts observed by the

writer, the Army required no proof, and the Navy required bid bonds of 10 per cent and also performance bonds of 25 per cent.

Form of Presentation of Negotiated Contract Quotations

To provide an example of the manner in which quotations for negotiated bids are submitted, let us review the form used by one Naval station for supply parts, as illustrated in Exhibit 2.

This form is given to the manufacturer who has been invited to bid, along with the drawings and specifications. It is titled "Price Agreement and Certificate on Preliminary Negotiations for Type B Form of Contract." It provides for the following:

1. Statement of ability to perform the contract.
2. List of material required.
3. Delivery dates and destinations.
4. Conditions of inspection.
5. Material to be furnished by the government. Showing quantity, description and price.
6. Conditions of payment.
7. A comment by the supplier regarding exceptions.
8. Statement of price analysis on a fair and reasonable basis.
9. Signatures and affirmation of accuracy.

The price analysis (item 8 above) has three columns. The first is headed "Company Estimate," the second "Government Estimate," and the third "Accepted Price." These provide a record of the negotiation and how the price finally agreed upon compared with the figures of each party.

A breakdown of the selling price shows the following:

a. Direct Material
b. Direct Labor
c. Factory Overhead Expense
d. General Overhead Expense
e. Contingencies, if any
f. Delivery Expense
g. Amortization of Special Plant Facilities as specified
h. Allowance for profit.

EXHIBIT 2

PRICE AGREEMENT AND CERTIFICATE ON PRELIMINARY NEGOTIATIONS FOR TYPE B FORM OF CONTRACT

Preliminary to the making of a Type B form of contract the following negotiations have been entered into for supplying the material or services to the government listed below between the U. S. Naval Torpedo Station, Newport, R. I., represented by , U. S. Navy, and the Company, City of , State of represented by (title).

1. The material or services are required under an emergency and the company has an organization, plant and facilities of sufficient capacity for doing such work, and is willing to do such work for the account of the Government to meet the emergency, except as specified below.

2. The following is a list of material required:

Item	*Description*	*Drawing No.*	*Total Accepted Price*
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....

3. DELIVERY CONDITIONS—The deliveries are to be made as follows:

Quantity.....	*Date*.....	*Destination*.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....

4. INSPECTIONS:

Condition .....
.....
.....
.....
.....

5. MATERIAL to be furnished by the government:

Quantity	*Description*	*Price*
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....

6. PAYMENT conditions are to be made as follows:

Item No. .....
Item No. .....
Item No. .....
Item No. .....
Item No. .....

7. Other items:

.....
.....
.....
.....
.....

8. Statement of Price Analysis on a fair and reasonable basis:

Particulars	*Company Estimate*	*Government Estimate*	*Accepted Price*
Direct Material			
Direct Labor			
Overhead Expense:			
Factory			
General			
Total Cost of Production			
Contingencies if any			
Allowance for Profit			
Delivery Expense			
Amortization of Special Plant Facilities as Specified			
Other Items			
Totals			

The above are true and correct statements of the negotiations in connection with fixing the prices for entering into a Type B form of contract. The prices accepted and mutually agreed to are considered to be fair and reasonable.

Representing the Government	Representing the Company
Signed	Signed .....
U. S. Navy	Title .....
Date	Date .....

The Bid Is Analyzed

The cost figures compiled by the government are not made available to the bidder. If the bid price is satisfactory, the order is given at once. If too high, the approximate amount which would be acceptable is made known to the bidder and the bid may be re-entered at once, if desired.

When costs are out of line the Navy negotiator will analyze the discrepancy according to the breakdown previously mentioned. Also, some help may be obtained in the form of a comparison of particular labor operation costs.

If the Navy feels that overhead costs are too high, they may ask for a detailed analysis of the actual overhead for some recent

period. If this contains elements which they do not admit as chargeable, then a corresponding adjustment is required.

Contingencies

The item of contingencies provided for under the breakdown is subject to the local interpretation of the term by the supply officers at this particular station. According to Webster, a definition of the word contingency is "an event or condition looked forward to as possible, or probable, or one dependent upon an uncertain happening." The Navy, however, defines it as a "planned extra expense," and expects you to state what it is that you expect to happen, when it is going to happen, and how much it will cost. This seems harsh treatment to a bidder who wishes to be protected against some possible loss, but it must be remembered that no provision exists in this form of contract for the government to recover this contingent amount in the event that it is not required.

The bidder is asked to assume all the risk on this fixed-price contract, and must seek an escalator clause or cost-plus contract if he wishes further protection. It is true that even contracts without the new re-negotiation clause may be subject to re-negotiation but this has not been considered a factor by either party to any of our contracts.

Critical Material Content Analysis

A most trying problem today is the procurement of materials. The cost accountant has his share of the difficulty, as he gives his services toward the analysis of the material content of the products he costs.

There are four reasons for obtaining a complete analysis of the materials necessary to produce:

1. To obtain an allocation of material for future production (PRP).
2. To assist your customers in obtaining a preference rating which will permit the manufacture of the desired article.
3. To justify to government auditors your past use of materials on authorized production or blanket priority.

4. To obtain information needed in answering government questionnaires regarding past and future consumption.

The cost accountant is in the best position to analyze material requirements because the information is obtainable from his cost records. It is necessary to increase the requirements over those on the engineering specification to provide for waste (cutting loss, short ends, chucking pieces, trimming etc.) and also for anticipated scrap loss (spoiled work.) The records should be compiled by grade of material (S.A.E. number or other identification) and also by size as purchased.

For greatest efficiency, a medium should be employed for these records that will permit them to be used in conjunction with raw material stock records. This permits the "assignments" of stock to be applied to the stock ledger leaving a remainder of "unapplied balance." For the use of the purchasing department, and for certain government reports, it is necessary to adjust the material requirements on a particular order by the amount of stock on hand. This is an additional reason for tying together the form and method of stock records and the material content analysis.

HEAT TREAT COSTS

By George T. Krider, Chief Accountant,
Caterpillar Tractor, Peoria, Ill.

WITH the introduction of high frequency electrical induction hardening as a part of our heat treat operations and with the increased tendency on the part of our factory to mix furnace loads of piece parts of different sizes, weights and quantities, our method of determining heat treat costs became inadequate.

In studying the necessary revisions of our system we were made conscious of the dearth of written material on this particular phase of manufacturing cost accounting. The methods which we have adopted, although not fully developed, are therefore, presented here—not only with the hope that they may be of some help to others with similar problems but also that these others will, in turn, participate in the development of both improved accounting methods and literature upon the subject.

Equipment

Our heat treating equipment consists of various types and sizes of heating units, each type performing certain operations varying according to the results desired. They comprise 150 units located in ten different manufacturing departments throughout the plant and they vary from a small 15″ long furnace to the carburizing furnaces, which are 65′ long, and from a capacity per hour of a few pounds to 3,500 pounds.

The principal heat treatments of metals in our factory are carburizing, annealing and normalizing, hardening, drawing and induction hardening.

Carburizing

The object of carburizing is to impart a hard wear-resisting surface to parts which are subject to unusual wear and which, at the same time, require a relatively high degree of shock-resistance. Carburizing in itself does not give either the property of hardness nor toughness to the steel but makes it possible to

develop these qualities through further treatment. Carburizing provides a means of imparting a high carbon wear-resisting shell around a low carbon shock-resisting steel, and makes it possible to obtain the best qualities of both in the same part. Generally speaking, carburizing is carried on by a gas—CO (carbon monoxide) in the pack method, and methane, ethane, etc., in the gas method. There are several ways of producing the gas and several ways of introducing the gas to the parts to be carburized. For simplicity let us say that the gas acts as a carrier for carbon, the steel receives the carbon, and the gas goes back for more carbon in a cycle which can be controlled. Necessarily, a surplus of carbon for the gas to carry must be supplied, since not to do so would end the carburizing as soon as the carbon supply was depleted. This surplus may be provided by a solid such as charcoal, charred bone, charred leather, etc. In our shop we use charred peach pits to which an energizer has been added as an agent which makes it easier for our gas to pick up the carbon in the peach pits.

Three different types of carburizing furnaces are operated—

(a) The gas batch box type in which the piece parts to be treated are packed in boxes in layers with the carburizing compound between each layer. The boxes are placed in the furnace at one time and left for a predetermined period dependent upon the depth of carbon case desired.

(b) The electric pusher type consists of four chambers having a capacity of twenty-six boxes which are packed in a manner similar to those in use with the batch type. When a box is pushed in at one end of the furnace it automatically ejects a finished box at the other end. The period of heating in this type is also governed by the depth of carbon case desired.

(c) The gas type units use gas as a carburizing agent—the pieces are merely loaded in alloy cans and lowered into a heated chamber having an atmosphere which is permeated with carbon forming gas. The load in these furnaces invariably consists of several different kinds of parts all requiring the same depth of case.

Annealing and Normalizing

Annealing is the heat treating process performed for the following reasons:

To increase ductility, softness and toughness
To improve machinability
To produce a uniform structure
To refine the crystalline structure
To relieve the internal stresses of forging and unequal cooling.

Annealing may be divided into three cycles; heating, holding at temperature and cooling. The variations of these cycles will depend on the kind of material and the result to be desired. The temperature used will vary with different materials from 1,500° to 1,700° F. The time at temperature should be sufficient to allow the material to become heated through its entire section and not so long as to cause coarsening of grain.

The softness obtainable varies with the speed of cooling. The more rapid the cooling, the harder the material will be. Slow cooling—that is, cooling in the furnace—will give the softest material. Variations of these conditions will govern the result and will depend on what is desired.

Heating and air cooling is called normalizing. In some cases the hardness obtained by normalizing is that which is desired in the finished part, so that this is the final heat treat operation. Certain important alloy forgings are both normalized and annealed to leave the piece in good machining condition and minimizes the distortion caused by later heat treating operations.

Both gas and electric furnaces of the continuous or pusher type are used for this treatment:

(a) The gas furnaces have a load of nine 48" grids and are divided into six chambers through which the work progresses. In the first chamber the pieces are pre-heated by utilizing the waste heat of the second and third chambers which are used for the actual heating. The fourth to sixth chambers also utilize the excess heat of numbers two and three, and permit a gradual cooling which allows an almost immediate unloading after the loaded grids have been pushed from the furnace by the reloading of the first chamber.

(b) The electric annealers operate in a similar manner, except that they have five chambers, the first chamber being the heating chamber and the other four utilizing the heat from number one chamber to allow for the gradual cooling process.

Hardening

The process of hardening of steel consists of heating and cooling operations which are carried out under controlled conditions with the purpose of obtaining desired physical properties. The variety of phases and applications of this process are so numerous that it is inadvisable to go into further detail.

Several different types and sizes of hardening furnaces are in operation in our plant—

(a) The electricity heated continuous rotaries in which the pieces are placed on a revolving table running at a controlled speed and from which the work is removed and quenched by the operator at the completion of each revolution;

(b) The conveyor type furnace operated on a principal somewhat similar to that of the rotaries in which the pieces are placed on one end of a continuous belt and automatically fall into a quenching medium at the other end;

(c) Various types of batch hardening furnaces in which complete loads are heated for prescribed lengths of time and then removed and quenched;

(d) Cyanide crucible furnaces for smaller parts requiring very thin case hardening. In this operation the pieces are immersed in molten cyanide and hardenned selectively or over the entire surface.

Drawing

Drawing is a process of tempering fully hardened steel and is carried out for relief of quenching stresses and for the recovery of a limited degree of toughness and ductility. It differs from annealing only in the lower temperatures used for a shorter period of time.

The draw furnaces, which include conveyor and batch types, are very similar in operation to the hardening furnaces.

The lead pot furnaces are merely pots of hot lead in which the pieces may be drawn all over or selectively.

Induction Hardening

The induction hardening units perform their function by means of high frequency current and in different machines may develop a frequency of from 3,000 cycles to 9,600 cycles a minute. The piece to be hardened is placed, by the use of suitable fixtures, in the center of a copper coil around which this high frequency current travels. The current in turn sets up an induced current in the piece which starts heating from the surface to the center. The depth of the hardness is controlled by the length of time the current is allowed to travel around the coil. This control is made automatic by the use of switches which turn off the electricity and immediately start a flow of water over the heated part of the piece.

The cylinder line induction hardening unit is automatic in operation except for the loading and unloading. The part is placed in a fixture, automatically moved into place, progressively heated and quenched for the full length of the inside surface and returned to the operator.

The crankshaft unit is manually operated except for the heating and quenching. This machine has eight stations, each adapted to a different bearing surface. The number of operators vary with the different crankshafts to be hardened. It is desirable to operate the different stations in sequence, necessitating each operator being on the alert to switch in his station at the time allotted to the particular bearing section for which he is responsible.

The track roller and sprocket units operate in a manner similar to the crankshaft units but with only one station.

The pin and shaft units are of a continuous process type, the piece entering one end and leaving at the other completely hardened and quenched.

Job Lot Costs Used Formerly

Our former method of heat treat costing was to obtain so-called actual costs on a job-lot basis. The costs consisted of direct labor,

furnace cost and departmental burden. The direct labor cost was obtained by means of job cards punched in and out by the operators for each piece part heat treated. When different pieces were loaded at approximately the same time in the same unit separate job cards for each piece part were punched and the elapsed time apportioned equally thereto. The furnace cost consisted of direct expenses of furnace operation and of certain indirect expenses that could be clearly allocated to particular heating units, each unit consisting of a furnace and its auxiliary equipment. This furnace cost was computed in terms of dollars per hour which were distributed to the cost of the product by means of furnace cards punched in and out for each piece part and handled in much the same manner as operators' job cards. Idle furnace cards were punched for intervals when the furnace was down; all furnace cards were balanced to twenty-four hours per day and a monthly tabulation furnished to the heat treating department showing time for each furnace segregated as to (a) regular idle shift, (b) at temperature awaiting work, and (c) cold—no work. Indirect expense of the heat treat department, which could not readily be allocated to heating units, was distributed to the product on a direct labor basis.

Considerations in Setting Standard Costs

Satisfactory heat treating cost information is dependent, to a considerable extent, upon the proper application of furnace operating costs, and every effort should be made, therefore, to so compute the "Furnace Hour Rates" through which these costs are distributed to the product that they reflect costs as accurately as is reasonably practicable.

In setting our new standards, therefore, our first step was to determine the standard furnace hourly rates. A complete list of furnaces and the equipment used therewith was prepared and the operating costs per hour computed for each heating unit, based on the best available information.

These costs include depreciation, repairs, insurance, taxes and supplies on the furnace and its equipment, a proportion of the building maintenance and depreciation, power or fuel, and all other charges which may reasonably be allocated to the individual heating units. The hourly rate was computed by using the normal

number of hours of operation for each unit, based on previous records. The hourly rates for heating units of like type and size were thereafter averaged to obtain more uniform results.

Setting Standards

In computing heat treat standard costs we have the following known facts which govern the amount of time taken to complete an operation.

1. The amount of time a given number of pieces of a particular type must remain in a furnace to attain a given temperature, and the time it must be held at that temperature.
2. The amount of man-power necessary to load, unload and operate the furnace and to quench the pieces properly.

When setting standards for individual parts, excepting those treated on continuous operations and induction hardening processes, we calculated the quantities of a given part that would be required to load a furnace or battery of furnaces, as the case may be, to the normal average full load. Therefore, for these particular parts we have—

1. Total furnace time divided by number of pieces equals unit furnace time.
2. Unit furnace time multiplied by number of workmen used to operate furnace equals unit direct labor hours. Unit direct labor hours times average wage rate equals unit direct labor cost.
3. Unit furnace time multiplied by furnace cost equals unit furnace cost.
4. Indirect expense in the heat treat department not allocated to heating units applied as a percentage of direct labor.

Parts treated by continuous operations and induction hardening processes were computed in much the same manner, except that for most induction hardening jobs we are using an energy and royalty cost in addition to our equipment cost per hour. It is also necessary that we use a given lot size with which to absorb setup time; for example,

Crankshaft 7B9656
Lot size 150 pieces
Set-up time 8 hours
Production 9 pieces per hour
Six operators for 1 machine
Equipment cost per hour $3.167

Example

LABOR:

Nine pieces per hour = .111 hours per piece. .111 hours for 6 operators at $.90 per hour = $.599 per unit Set-up cost 8 hours × $.90 per hour ÷ 150 pieces = $.048 unit cost for set-up. Total unit direct labor cost = $.599 + $.048, or $.647.

FURNACE COST:

Station	*No. of shots*	*KW per hr. used*	*Duration of heat in hours*	*KW used per station*
1	3	.220	.0033	.726
2	3	.220	.0033	.726
3	4	.265	.0032	.850
4	1	.260	.0013	.338
5	1	.230	.0013	.300
6	1	.230	.0011	.253
7	1	.150	.007	.105
Total KW hours.....				3.298

3.298 KW hours @ .007 = .023 cost per piece.
.111 hours @ furnace hourly cost of $3.167 = $.352 unit furnace cost.
Total unit furnace cost = $.352 + $.023, or $.375.

BURDEN:

Departmental burden applied as previously explained, or 50 per cent of unit direct labor, $.324.

ROYALTY:

Royalty, paid on the induction hardening process, applied to

cost of this particular part as specified in license agreement $1.10.

SUMMARY

Direct labor	$ .647
Furnace	.375
Burden	.324
Royalty	1.100
	$2.446

In measuring our standards with actual departmental costs and for the preparation of accounting entries we make use of punched card tabulating equipment.

Production Cards

A heat treat production card is used to report heat treat production. This card is arranged to provide the following information:

Furnace number.
Part number.
Number of pieces.
Kind of heat treatment (anneal, carburize, burden, etc.)
Direct labor unit cost.
Burden unit cost.
Furnace unit cost.
Royalty unit cost.
Direct labor total cost.
Burden total cost.
Furnace total cost.
Royalty total cost.

Daily production is reported by the clerks in the heat treatment department who write a card for each separate part number and specify on the card the furnace number, part number, quantity heat treated and kind of heat treatment. The production cards are forwarded to the accounting department where the above information is key-punched into the cards.

Application of Standards to Production

A file of standard unit rate cards, also on tabulating cards, is maintained in the accounting department. These cards contain

punching of part numbers, kind of heat treatment, and standard unit cost of labor, burden, furnace cost and royalty. At the close of each month the rate cards are mechanically merged with the production cards and unit costs of labor, burden, furnace cost and royalty are gang punched into the production cards. The production cards are then run over the multipliers multiplying the unit costs by the number of pieces which had been previously key-punched.

The production cards are then tabulated to obtain the total production for the month at standard costs. From this tabulation the following information, based on standard costs, is obtained:

1. Total direct labor
2. Total burden
3. Total furnace cost
4. Total royalties

Development of Variances

The above totals compared with the actual departmental costs of the heat treat department provide the variances for each of the above elements of cost.

Heat treat salvaging, re-heat treatment or any heat treatment other than regular production are reported on different colored cards so that they may be deleted from our entry to inventory and distributed to such other accounts as they may affect.

The production cards may then be used to provide various data to the heat treat and metallurgical departments by tabulating to show total production by furnaces, kind of heat treatment or part numbers, or any combination thereof.